

each other in dodging it. The expression used by them was "Marndwullun no good for fight; if he no hit 'em man, might come back and hit your friend beside you." I questioned the black fellows as to whether they thought a boomerang could be thrown so as to return to the hand of the thrower. Seven said "no," and characterised the statement as "jetbollan," i.e. a falsehood; the eighth said he once made a boomerang that when thrown on a calm day with great care would gyrate round and round until it descended to the ground not far from him, moving as slowly as a leaf falling from a tree, and that he once ran forward and nearly caught it. He said also "no Kurni (black fellow) can catch a wunkun when he flying—he would cut his hand open."

All the black fellows were unanimous in stating that a boomerang when it has struck anything ceases its course.

I have now stated all that at present suggests itself as to the boomerang. I fear that I may have trespassed too much on your space and on the patience of your readers.

Bairnsdale, Gippsland, Victoria, ALFRED W. HOWITT
March 3

Fertilisation of Flowers.—The Cuckoo

As a fact interesting in connection with the fertilisation of flowers, I have observed that in *Scabiosa arvensis* the stamens are elongated and the anthers ripened successively—not simultaneously—in each individual floret, the first having fallen off the filament, while the fourth is yet colourless and curled up in the tube of the corolla, the other two being in intermediate stages of development.

May I also state in reference to the Cuckoo, that a rhyme well known in Somersetshire, runs thus:—

"In April, come he will,
In May, he sings all day,
In June, he alters his tune,
In July, he prepares to fly,
In August, go he must."

By which it is clearly not meant that the Cuckoo ceases to sing in that part of the country at Midsummer. This break of note in June is generally to be noticed about the middle of the month. I, this year, heard it for the first time on the 28th May.

Ealing CHAS. FRED. WHITE

The Cuckoo

IN connection with the notes of Mr. Adair and Mr. Joyner in NATURE of July 6th and 13th, let me record that the Cuckoo has not even yet left us in the Midlands. I heard it only last evening near to my own house. There is a popular rhyme, long current in Derbyshire, concerning this bird. One couplet tells us the Cuckoo may be heard

"In April, May, June, and July,
If she sings any longer she'll tell a story;"

so that even this rude rhyme shows that it is not expected to depart earlier than this month. LLEWELLYNN JEWITT

Winstor Hall, Derbyshire, July 15

ABSTRACT REPORT TO "NATURE" ON EXPERIMENTATION ON ANIMALS FOR THE ADVANCE OF PRACTICAL MEDICINE¹

IV.

Experimentation for Determining the best means of Restoring Animation after some Forms of Accidental Death.

THE frequent occurrences of death from the administration of chloroform and other agents of the anaesthetic series led me very early to experiment for the purpose of discovering the best means of restoring life after such accidents. I commenced this research in 1851, and have continued it up to the present time. I consider it to have been one of the most fruitful in useful practical results. The details of the work have been communicated at various times to the world of science, and at considerable length. They formed the subject of a special report to the British Medical Association at its meeting in London in 1862. They formed the subject of a report to the Royal Society in 1865. They were con-

¹ Continued from p. 199.

tinued in the Croonian Lecture delivered before the same Society in 1873, and they were introduced into various lectures on experimental and practical medicine, and into reports on the physiological action of organic chemical compounds made to the British Association for the Advancement of Science.

As the account of these inquiries covers a great deal of ground and brings into light many curious and interesting topics, I shall devote a little extra time to the abstract of the experimentation.

Method of Experimental Research.

The mode of experiment in this research has consisted chiefly in testing the action of the narcotic vapours; the vapours of chloroform, ether, nitrous oxide, carbonic acid, choke damp, carbonic oxide, hydrocyanic acid, methyl, chloral hydrate, and others similar. Some inquiries have also been made relative to instant death by mechanical and electrical shocks, and to death by drowning and cold.

In every case the animal has been submitted as painlessly and rapidly as possible to the process which we call death. The rapidity and painlessness were essential to the experimental inquiry; because the more rapidly and the more placidly the animation is suspended, the less is the body exposed to the risk of organic injury.

In the course of observation two steps have been followed.

I.

In the first line of inquiry the animals have been allowed to die without any attempt to restore life, the object being to ascertain why death took place. After death the organs of the body have been examined in order to determine what was the action of the destroying agent on them. How did it arrest the living action?

The first question asked had relation to the condition of the lungs:—Were they left bloodless, containing some blood, or congested with blood? The second question had relation to the heart:—Were its cavities left full, or empty of blood; were they distended or collapsed; was the blood left in the cavities of natural or unnatural colour; were the muscular walls of the heart still excitable to motion, or were they quite inactive; if the muscular walls were inactive were they rendered inactive by rigidity of contraction or by relaxation? The third question had relation to the blood:—Had the blood undergone coagulation, and if it had not at the time when the examination was made, how long a time elapsed for the completion of the process? What was the condition of the blood corpuscles; were they scattered or massed together, were they perfect in outline or irregular? What was the colour of the blood on the two sides of the circulation; was the venous blood darker than the arterial, or were the two kinds of blood mixed in respect to colour? Were any gases escaping from the blood or had any escaped? Had the fibrine escaped from the other constituent parts? Had the blood accumulated in any of the vascular organs, or had it exuded from its vessels in whole or in part? The fourth question related to the state of the nervous organs, the brain and spinal cord:—Were these organs congested or free of congestion? Was there any effusion of blood or of serum into them? Was the appearance of the white and grey matter natural or morbid? Were the membranes vascular or pale? The sixth question had relation to the state of the visceral organs in the cavity of the abdomen:—Were the kidneys free of congestion, or were they congested? Was the colour of the intestines natural? Were the liver and spleen congested or free of congestion? The seventh question had regard to the muscular system:—How long a period elapsed before the muscles became spontaneously rigid? After what modes of death from the different agents did the muscles continue most active under the influence of the galvanic current? What sets of muscles first ceased to respond to the current, the muscles of respiration or the muscles of

locomotion? What other stimulants than galvanism would excite muscular movement after systemic death?

The above-named questions follow in series in relation to the condition of the animal body and its parts after death. In addition other observations were made to which it is necessary to refer.

The influence of the narcotics on the temperature of the body immediately before and after death was studied with much care. The variations of the animal temperatures under different degrees of natural atmospheric temperatures, from summer heat to extreme of winter cold, were noted. The different modifications of temperature that occurred in different organs of the body, brain, stomach, lungs, heart, liver, and abdominal cavity immediately after death were also observed.

The influence of the anaesthetic vapours on the minute or capillary circulation of the blood was determined by microscopical observation. In these experiments the web of the foot of the frog was made the field of observation. The animals were narcotised with the different vapours, and while narcotised the state of the circulation through the minute vessels, arterial and venous, was recorded during every stage of narcotism, and was compared with the state of the same parts that existed previous to the induction of the narcotic condition. The information sought for in this part of the inquiry related to the action of the narcotic vapour on the circulation of the blood corpuscles through the minute vessels; the changes of form in the corpuscles, red and white, if any changes occurred in them; the changes in the calibre of the vessels on the arterial and venous side; the point of arrest of the circulation through the vessels when the circulation finally stopped; the point of return of motion if the circulation were restored; and, the effect of various changes of external conditions such as warmth, cold, and moisture on the circulation during the stages of narcotic sleep.

One other important part of this line of inquiry was the determination of the conditions in which an animal body assumed to be dead could be best kept so as to retain those states of organs and parts which are favourable to the re-establishment of living motion. Should the body be left in a warm or a cold atmosphere? What circumstances determine the suspension of the process of coagulation of the blood and of cadaveric rigidity? Briefly stated these were the points of inquiry sought for under the first direction of research. By them I have been able to distinguish the conditions in which all the known anaesthetics leave the organs of the body when they kill.

II.

In the second line of inquiry the objects sought after were the rational means, suggested by the previous inquiries, for recalling animation after the signs of life have ceased. In this direction the following questions were asked:—

1. What is the precise value of *artificial respiration*? What is the most perfect method of carrying out artificial respiration? How long should the process of artificial respiration be continued, and what are the proofs that its continuance will be useless? When it has proved useful in restoring natural respiration, how long should it be continued? What dangers are connected with its employment?

2. Is it possible when the phenomena of suspended animation are present, to restore the circulation? By this process, to which I have given the name of *artificial circulation* (*British and Foreign Medico-Chirurgical Review*, April, 1863), I tried to restore the current of blood through the vessels, by transfusion of other blood; by mechanically pumping the blood within the veins of the dead body, over the lungs into the arterial circuit; by attempting to draw the blood over into the arterial circuit from the venous circuit; by altering the position of the body in alternate motion up and down,

3. Is it possible to combine artificial respiration with artificial circulation? In this endeavour I tried the combination of the two methods, and with the hope of being able to drive or draw a current of blood over the lungs while the blood remained fluid, and of being able also to aerate the blood in its passage by keeping up artificial respiration.

4. Is it possible to utilise the galvanic current so as to restore animation? In this inquiry the galvanic current was employed so as to call into play the action of the muscles of respiration: the heart: the voluntary muscles.

5. Can the heart, after it has stopped, be excited into motion by injecting into it agents which stimulate it to contraction? In this inquiry ammonia and other excitants were injected into the heart, while artificial respiration was maintained.

6. What is the value of external warmth in various degrees for restoring animation? In this research the effects of warm external applications, warm sand, moist warm air, dry warm air, moist warm straw, and other similar means were carefully tested.

In the briefest terms I have thus sketched out the mode of inquiry adopted in the course of experimentation now under notice. Fuller details are recorded in the paper published in 1863 in the *Medico-Chirurgical Review*, but these now given are sufficient for this abstract.

RESULTS.

The practical results which have followed on these researches are very numerous. I will write those which seem to be most practical and useful.

On Artificial Respiration.—In respect to artificial respiration the following facts were learned:—

If artificial respiration be sustained, even with an atmosphere of chloroform that is sufficiently narcotic to keep up deep narcotism, the action of the heart continues and recovery of life is possible. In brief, the mode of death from chloroform and perhaps from all the other narcotic vapours is actually due to the arrest of the current of blood through the minute vessels in the circuit of the lungs.

Artificial respiration, when perfectly carried out, was found sufficient to restore life after natural respiration had entirely ceased, and when all external evidence of motion of the heart had also ceased. To make this fact matter of direct application, I invented a double-acting elastic hand-bellows, which performed when in action the double purpose of emptying the lungs of their contained air by one movement, and of filling them with fresh atmospheric air by another movement. I also arranged the instrument in such manner, that on emptying the lungs of air a current of blood is mechanically drawn upwards from the right side of the heart, by which the oppression of the right side of the heart from tension is removed, and its muscular contraction is recalled into play. My latest instrument for this purpose is now so graduated, that measured quantities of air can be withdrawn and introduced, and the physico-chemical action of the lungs can be imitated with the greatest refinement, and with results that are different to any that have been gained before. Thus, after death from some of the narcotic vapours I have been able to restore life as long as eleven minutes after all the external signs of life have ceased. The results of the experiments proved also that when once the natural respiration is established the artificial ought to cease, so that the enfeebled circulation and respiration may return into play together.

Further, the experimentation showed that artificial respiration, while it may be made, by delicate using, an all but certain means for the restoration of life after death from narcotic vapours, it may by bad use be made the certain means of ensuring death; that in performing it any rude movement of the body, or any violent inflation of the lung, or any attempt to inflate the lung while the lung is full of air, and the right side of the heart, full of blood, is sufficient to complete the process of destruction of balance and to cause unavoidable death. In a word, the experimentation

showed that as with a fire that is well-nigh burned out we can restore action by laying new fuel lightly on the remaining flame, and then by gentle blowing can communicate the flame to the new fuel, so in artificial respiration the same delicacy of procedure will reproduce the vital flame.

In the absence of experimentation these facts could never have been learned. It was necessary to see the effects of various methods under various conditions, and under various circumstances in order to arrive at certain conclusions. A century of observations on men subjected to accidents that destroy life would not have taught so much as was learned in a few hours from the observations on the inferior animals.

Artificial Circulation.—The inquiry on the subject of artificial circulation proved that the attempt to establish the circulation by injection into the vessels, or by forcing the blood over the lungs, or by drawing it over in combination with artificial respiration, failed by reason of the coagulation of blood which followed such attempts. Some countenance was given, by the experiments, to the attempt to encourage a current of circulation by the process of raising and depressing the body so as to place the head at one moment below the level and at another moment above the level of the body; but on the whole the effort to restore the circulation through the lungs was most expedient by the simple plan of artificial respiration carried out as above stated.

Use of Galvanism.—The research instituted to test the value of galvanism as a means of restoring animation had a most important practical bearing. By regulating the intermittent current with a metronome I found it possible to make the respiratory muscles of an animal recently dead act in precise imitation of life. I also found that the heart could be excited into brisk contraction by the same means. But the result came out that by this method the muscles excited by the current dropped quickly into irrevocable death through becoming exhausted under the stimulus, and that in fact the galvanic battery, according to our present knowledge of its use in these cases, is an all but certain instrument of death. By subjecting animals to death from the vapour of chloroform in the same atmosphere, and treating one set by artificial respiration with the double-acting pump, and the other set by artificial respiration excited by galvanism, I found that the first would recover in the proportion of five out of six, the second in proportion of one out of six. Further, I found that if during the performance of mechanical artificial respiration the heart were excited by galvanism, death was all but invariable. The explanation of these experimental truths is illustrated by a simple simile. If an animal reduced in power to the last degree from want of food be carried to a place of succour, it may recover; but if it be stimulated or forced to walk to the place it will possibly die on the way. So with a man or animal under prostration from shock or narcotism; if the surgeon uses his own force for the restoration of the enfeebled muscles of the man before him he may restore the muscles to power; but if he uses up the last remaining force in the muscles of his patient by stimulation he will kill them outright. Considering that in the large number of instances of sudden death by accident, the first thing "tried" for restoring life is the galvanic battery, the information on the subject thus yielded by experiment, and which could have been got in no other way, is a result which, though unexpected, is none the less valuable. Indeed the peculiarity of experimental pursuit is that something unexpected in result is always learned, and is almost always useful.

Injection of Stimulants.—The effect of injecting ammonia, and other stimulants into the heart for the purpose of exciting the walls of the heart into contraction, was found to be as faulty as the application of galvanism for the same purpose. It produced a final contraction which was fatal.

Use of External Warmth.—The research on the action of warmth on animals under suspended animation was

singularly interesting. I found that when an animal under a narcotic is still breathing, however faintly, the restoration of the animal warmth is often alone sufficient to restore life. This came out of the observation of the action of narcotics in reducing temperature, and in my first researches on chloral hydrate I showed that of two animals under the same lethal dose one was safe to recover in a warm air, while the other in a cold air would die. These facts relate to animals which are still breathing though all but dead.

On the other hand, I discovered that if an animal had actually ceased to breathe, the most certain way of ensuring its death is the exposure of it to heat; the most certain way of retaining it in a condition for possible recovery and of retaining its muscular irritability under stimulus is the exposure of it to cold. Heat I found excites the final muscular contraction and causes coagulation of the fibrine of the blood; cold suspends both. Thus in a warm-blooded animal exposed, after its death from chloroform, to extreme cold in a dry air, I found every muscle in the body that I could reach vigorously active under re-applied warmth and galvanism three hours after death; while in fish and batrachians I found it possible to restore life altogether after they had been accidentally inclosed, that is to say, frozen up in ice. As we arrive at clearer knowledge of the means of restoring animation in man, these facts will have a bearing of the extremest value. Already they indicate that in the death of the human subject by drowning and cold, attempts to restore life are demanded even hours after the occurrence of the accident.

Lastly, on this head, the experimentation taught me that while in the process of resuscitation it is very bad practice to immerse the body in a heated medium like hot water, it is of the utmost importance to establish the artificial respiration with a warm and dry air. Such an air prevents condensation of water in the bronchial tubes, quickens the process of oxidation of blood, and allows the body to become warm from its own natural centres of vital heat.

PRACTICAL APPLICATIONS.

The experimental inquiry herewith briefly stated is too new to have brought forth much fruit. The grand practical results for which it was pursued have to follow in course of years. Some results have, however, already been realised.

Immediately after chloral hydrate came into use, the dangers from its use were found to be imminent. I was able to point out even before such dangers had occurred that the cause of danger was reduction of animal temperature from the agent, and that in treating a person poisoned with chloral two things were required, viz., to maintain a high atmospheric temperature, and to give warm food. Twice I have been summoned to these accidental poisonings, and in both instances I have saved life by these simple and purely scientific modes of cure. Probably after a number of deaths of men from chloral, it might have been learned that the cause of death was the reduction of animal heat. The fact gained instantly by observation on the lower animals supplied the knowledge in advance of the accident.

In two instances in the human subject in which after the performance of the operation of tracheotomy, life has become suspended from obstruction to the entrance of air into the lungs below the artificial opening, the obstruction has been removed, and afterwards by means of artificial respiration carried out with the instrument I have described above, life has been restored after all the ordinary evidences of death were manifested. In one of these examples of restored life the recovery was complete and the patient is now as well as ever he was. But for the long period of eleven minutes he lay in all the character of death, depending solely for returning life on the surgeon who supplemented his respiratory power and who gently fanned back into life a flame which had ceased for ever if scientific experimentation on the lower animals had not shown the possibility of its return by the hand of science.

(To be continued)